Designing for Reflection on our Daily Mental Workload

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This paper presents a research plan, at the outset of new doctoral research, designing for reflection on cognitive personal informatics and self-tracking of Mental Workload. The research will build upon the Mental Workload cycle, considering how people reflect on their patterns and transitions between levels mental workload. The research is driven by the arrival consumer neurotechnology and how they will relate to and/or change our understanding of personal informatics, as we bring cognitive activity into the mix. The doctoral research will involve three phases of work 1) Co-Design Workshops to understand mental models from how people reflect on their own cognitive activity, 2) longitudinal tracking of Cognitive Personal Informatics, and 3) understanding cognitive goal setting.

CCS Concepts: • **Human-centered computing** → **Empirical studies in HCI**; **HCI theory, concepts and models**.

Additional Key Words and Phrases: Mental Workload, Personal Informatics, Cognitive Personal Informatics

1 INTRODUCTION

Visualising physical activity data has been applied to a range situations such as counting steps, heart rate, tracking calories, etc. and users benefit from regularly checking their physical health and reflecting on it in relation to personal goals. Indeed a lot is known about Personal Informatics [6], thanks to the now ubiquitous automatic tracking of different physical activities with wearable technologies. However, new consumer neurotechnology devices are arriving, e.g. Mendi[1], and Muse[2], that help us to track a new form of data that is very different. Where we know a lot about how people track their automatically captured physical activity data, we do not yet understand the goals that people have for their cognitive activity, as measured by these new devices, and how they will reflect on different forms of Cognitive Personal Informatics [17].

Wilson et al [17] proposed (see Figure 1) that cognitive activity tracking is approximately 20 years behind physical activity tracking. Despite current scientific work struggling to reliably high accuracy at classifying cognitive states, the private sector is bringing this to the consumer market. This creates an urgency to focus on research questions that are related to how personal informatics apps will be designed to convey this data to people, and how people will reflect upon it. The objective of my doctoral research is to design interfaces for reflecting on personal cognitive activity tracking. We aim to understand how people comprehend this kind of data and its meaning, how they set new goals

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[1]https://www.mendi.io/
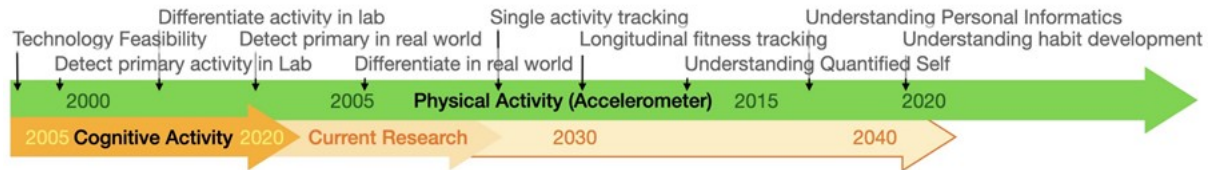
[2]https://choosemuse.com/

Fig. 1. A comparison between cognitive activity tracking and physical activity tracking (Wilson et al, 2022 [17])

in relation to it, and how they reflect on their daily activity based upon it. The research will use Mental Workload, described further below, as an emotionally agnostic grounding concept for Cognitive Personal Informatics. We will build upon the established understanding of personal informatics, the existing knowledge about subjectively rated self-tracking (e.g. mood and stress), and make use of examples of consumer neurotechnology that are available to end users.

2 RELATED WORK

2.1 Personal Informatics

Personal informatics in HCI is defined as *"a class of systems that help people collect personal information to improve self-knowledge"* [6]. In early defining work in the area of Personal Informatics, Li et al discuss some of the origins, including Buckminster Fuller who obtained a scrapbook called "Dymaxion Chronofile" in which he documented every 15 minutes in his life. Li et al then introduced the stage-based model of personal informatics [5], which is formed through the long term collection of data that can be used by people to evaluate and explore their statistics.

The interest in physical effort has been the centre of attention for personal informatics for the last few decades. Monitoring fitness is now widely available via wearable technology such as smart watches that collect and analyse data about different forms of physical activity [14]. Habit formation through technology [15] emphasises the importance of personalisation, where people prefer keeping track of their own data especially that they now are familiar with such technologies hence fitness mobile apps [2]. Some personal informatics does focus on concepts like stress and mood, including using physiological indicators [10]. Their research focused on multitasking and its association with stress management, whilst considering group of aspects such as social media time, sleep schedule, and computer usage.

2.2 Mental Workload

"Mental Workload (MWL) can be both good and bad" [1]. High MWL is not supposed to be considered damaging, yet research typically treats it as something to avoid or that high MWL indicates that a system or task is bad or hard to use [12]. Similarly, low MWL is on its own neither good nor bad: we may be resting, a task may be not challenging, and lower MWL may indicate that we have improved at performing a task [18]. Most MWL is studied in relation to an immediate task: is it high when interacting with software [7, 8], or too high during safety critical tasks like air traffic control [9]. MWL has also been studied in workplaces to measure its effect on productivity and task completion [11]. When viewed over time, however, as to what the ideal MWL is across a whole day, our own research implies that a balance of different levels, going in cycles, is probably the best outcome [17]. Where current research aims still to accurately classify different cognitive states in and out of the lab, personal consumer neurotechnology is arriving *en masse* and our research focus has shifted towards how we will behave when we can track this data about ourselves.

Like stress, changes in MWL can be measured using physiological changes [1], but is most commonly evaluated using multi-dimensional self-reporting techniques like NASA TLX [3]. This highlights the complexity behind considering this as a concept for cognitive personal informatics. Unlike physical activity (where by default more exercise is considered better) and self-tracking of symptoms of e.g. stress (where by default less is considered better), there are many complexities to cognitive concepts like MWL, effort, and fatigue. Given that our recent findings highlight that good patterns of MWL relate to a cycle, it may be that personal informatics relating to sleep may be a good theoretical starting point.

3 RESEARCH QUESTIONS

The aim for this PhD, which began Feb 2023, is to design apps allowing people to reflect on their mental workload efforts throughout the day. This supports evaluation on how people interact with such data, to understand their lives through managing mental workload as a limited resource. In doing so, this project aims to validate and potentially build upon the MWL cycle (Figure 2) by Midha et al [12], where participants tracked their MWL levels (high, medium, and low) every half hour across a week. Each level of MWL only led to negative consequences when participants spent too much time in them, and she found that patterns in this cycle transitions are a key to understanding participant's MWL flow.
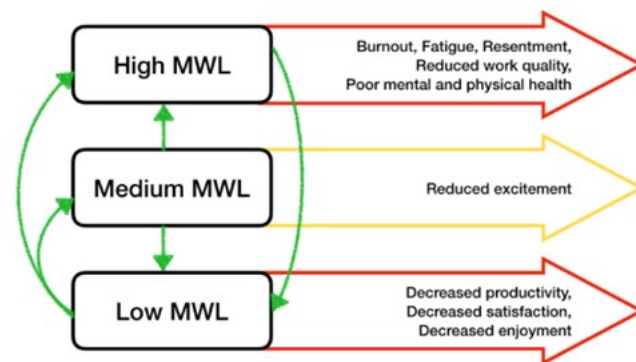

Fig. 2. The Mental Workload Cycle (Midha et al 2022 [12])

RQ1 How will people aim to improve their lives by taking and reflecting on cognitive activity measures about themselves?

Personal informatics has had a big impact on how users modify their physical health, whether for dieting purposes or general workout activities. Unlike physical measurements, cognitive activity and MWL tracking is focused on how users choose to interact with it. For instance, it is straightforward to reflect on the amount of calories conserved, but it is a complex to consider whether different mental workload levels were good or bad, when, and why.

RQ2 How should these devices convey personal informatics about complex cognitive concepts such that they provide meaningful insights for users?

In order to use this new form of cognitive personal informatics to improve their lives, users will likely take assumptions from and build upon their knowledge of physical activity tracking data. This research question involves both understanding common conceptual understanding of cognitive activity, and how long term data visualisations provide

insightful patterns for users. Interaction with such systems must be studied via workshops to further understand human behaviour towards tracking cognitive data.

4 RESEARCH PLAN

Through this PhD, we plan to go through a Design, Deployment, and Evaluation cycle.

4.1 Phase 1: Co-Design Workshops

In the first year of the PhD, we plan to use co-design methods in workshops with participants to enhance creativity for prototype designing process [13], using technology probes [4] to develop participants understanding of neurotechnoloy, as a new and emergent technology, prior to taking part.

4.2 Phase 2: Tracking Cognitive Personal Informatics

Based on the conceptual design outcomes from phase 1, we plan to design and build a self-tracking app in order to perform longditudinal research as a follow on to Midha et al's study of MWL in everyday life [12]. We plan a mixture of self-reflective daily assessments and experience sampling [16] in order to gain insights across time that help to provide insights into the proposed mental workload cycle [12]. Further, we expect to expand our conceptual understanding of MWL, and expand upon our design concepts from Phase 1.

4.3 Phase 3: Understanding Goal Setting and Coaching

Continuing to make use of the developed app, and building upon the insights gained from participants in phase 2, we plan to run more of an intervention-based study that asks participants to adopt certain goals or daily planning tasks relating to their mental workload. This approach would aim to further validate prior findings, test hypotheses from our findings, and consider more design recommendations.

5 CONCLUSIONS

This workshop paper describes the proposed research plan at the outset of a new PhD, starting Feb 2023. Building on top of the most recent research into mental workload [12] from our Brain Data Group[3], we aim to understand how new consumer neurotechnology will relate to and/or change our understanding of personal informatics, when we bring cognitive activity into the mix. We aim to design for reflection on this new form of data, and understand how people will use it to interpret their lives and behaviours.

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